Progress Report on Lidar for Lateral Mixing (LATMIX) Directed Research Initiative (DRI)

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LONG TERM GOALS

The current work is a collaboration between J. Ledwell and E. Terray (WHOI), M. Sundermeyer (UMass Dartmouth), and B. Concannon (NAVAIR). We proposed to conduct a series of dye release experiments in the seasonal pycnocline and upper ocean to examine lateral dispersion and frontal processes on scales of 10 m to 10 km as part of the ONR "Scalable Lateral Mixing and Coherent Turbulence" DRI. The vertical and horizontal dispersion and advection of the dye patches will be monitored on spatial scales of meters to several kilometers in the horizontal, 1-10 meters in the vertical, and on time scales of minutes to hours, up to 4 days. Sampling of the dye will be performed using airborne LIDAR, as well as in situ sensors lowered and towed from a ship. Additional measurements of optical characteristics, hydrography, currents, and internal wave characteristics will be used to identify particular driving mechanisms of the observed dispersion. The dye experiments will be coordinated with AUV and microstructure measurements proposed by other investigators to discern forcing mechanisms responsible for the dispersion. The dye experiments will also be guided by numerical modeling process studies proposed by other investigators under the DRI, and will provide data for testing such models.

OBJECTIVE (Lidar Specific)

The primary mission for the lidar system is to repeatedly measure the evolving dye patch in terms of dye concentration, 3D position and time at special scales of 5 meters horizontally and 1 meter vertically. The goal is to re-map the entire dye patch (many square kilometers) at approximately ½ hour intervals. From the lidar data series and in situ measurements the processes of lateral mixing can be interpreted.

APPROACH (Lidar Specific)

In 2008 and 2009 a single channel lidar system was flown by NAVAIR on a commercial Twin Otter aircraft. The Navy application required a 480 nm (blue) laser source and very high signal recording precision. To accomplish the goals of the LATMIX DRI the following system changes must occur: 1)

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To receive the laser return signal (blue) and dye fluorescence signal (green) the lidar receiver needs to be divided into two channels., 2) to achieve 1 meter vertical resolution, the laser pulse duration needs to be reduced from 30 nanoseconds to 10 nanoseconds via a pulse chopper, 3) to maintain waveform capture dynamic range a logarithmic amplifier must be employed and 4) real-time software must be developed to create coarse dye intensity versus position maps and download them within minutes.

In 2008, when Lidar for LATMIX was proposed, the lidar system was installed on a commercial Twin Otter aircraft. The Navy program that supported the lidar system and aircraft continued into 2009 but was not funded in 2010. The Lidar for LATMIX proposal did not include funding for supporting an aircraft outside of the LATMIX field testing timeframes. Eventually, a different Navy program picked up the support of the lidar system and in July of 2010 system installation into a Navy P3 was started. Unfortunately, an unresolved engineering/safety certification of an earlier installation was brought to light by the installation of the LIDAR system in the aircraft. While the certification issue has been resolved, over a month was lost in the process and the lidar could not participate in the 2010 field study.

WORK COMPLETED AND RESULTS

1) In December of 2009 a LATMIX planning meeting was conducted in Seattle, WA. At the meeting the lidar system and the measurements it would make was presented to the LATMIX community. Communication with Ledwell, Terray and Sundermeyer continued throughout 2010.

2) The lidar receiver modifications to achieve two simultaneous optical channels were designed and reviewed and long lead items were procured. In Figure 1 a model of the new design and the ray trace are depicted. System software modifications were made to control the two photo-devices and acquire the two data channels. Custom optical filters were purchased to select the proper wavelengths for each optical channel.

3) The laser pulse chopper was designed, implemented and tested in the laboratory. A 10 nanosecond pulse was achieved, which will equate to a 1 meter vertical resolution from the lidar signal.

4) Logarithmic amplifiers were selected and tested. The amplifiers will re-map the 4 orders of optical dynamic range into the digitizers 2 orders of electrical dynamic range with a loss of some precision.

5) Software to provide real-time maps of the dye return intensities was developed in collaboration with E. Terray. The software is untested at this time.

6) The single channel lidar system is installed in the Navy P3 aircraft. Preparations are being made for short shake down flights and possibly a very small scale dye release flight.

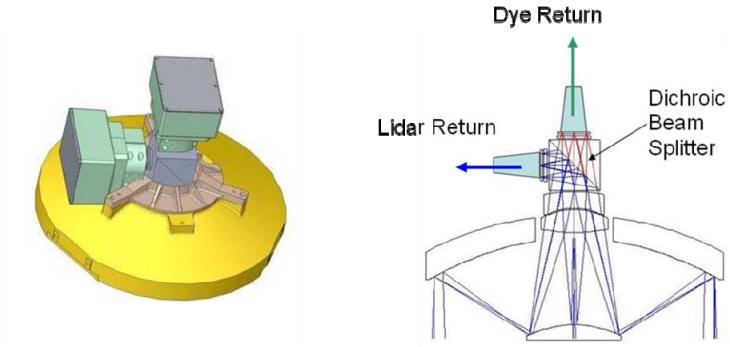

Figure 1: Receiver design for Simultaneous collection of Blue backscatter and Green dye fluorescence

BUDGET PLA2

Received $50k June 2009, $110k October 2009, $160k April 2010 = Total $320k
Due to the shift from the Twin Otter to the P3, more funds will be expended on aircraft costs but less funds will be expended on travel and per diem costs. The P3 will leave and return to Patuxent River for all LATMIX filed tests flights. The net hours on station is equivalent.

FY09/FY10		***Comments***
Modify Lidar	$160k	Funding spent, in-house labor, on contract for system modifications
Limited Field Test A/C	$130k	Funding Received, pending data flights, Navy support funtions
Limited Field Test Navy	$ 30k	Funding Received, partial expenditure for Navy support functions
TOTAL	$320k	~$110k will be available for flight tests after shake down flights

FY11		
Field Test A/C	$515k	
Field Test Navy	$100k	
Data Q/A and Analysis	$100k	
TOTAL	$715k	

FY12-13
Analysis, synthesis and publication $150k

REFERENCES